



Hydro-thermo-chemical study of CO₂ rich-brine percolation through fractured cement

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The storage of CO₂ in geological formations is still a new technology and many questions remain unsolved, in spite of the considerable progress achieved over the last decade. To ensure the environmental acceptability and safety of CO₂ storage over long durations, it is essential to quantify the latent and catastrophic risks of confinement failure. Pressure-driven flow through hydraulic discontinuities, such as rock fractures or damaged well cements, may produce rapid and localized CO₂ seepages, knowing that cement integrity is the most important indicator of wellbore integrity (Watson, 2009).

Interaction between CO₂ and cement materials induces carbonation of cement, which is a complex process strongly related to physico-chemical mechanisms like diffusion and transport and chemical reactions. Portlandite [Ca(OH)₂ CH] and Calcium Silicate Hydrates (CSH) are progressively consumed to produce calcium carbonates, silica amorphous gel and water.

To characterize the hydro-thermo-chemical reaction between CO₂ rich-brine and cement, we realized percolation experiments at in situ condition, T = 80°C and P = 10 MPa. First, we injected cement equilibrated water through the fractured sample and then to simulate CO₂ leakage from limestone reservoir, we injected CO₂-rich brine. We continuously measured the permeability changes of the sample fracture and sampled the outlet fluid to analyse the ions concentrations by ICP-AES. We observed after experiment by Environmental Scanning Electron Microscope (ESEM) in both side of the cement sample fracture a carbonated zone, a carbonation front, a dissolution front and a non-carbonated zone. The carbonated zone contains calcium carbonate, silica gel and calcium-depleted calcium silicate phases. We measured the permeability change during experiments. The permeability change is related to the precipitation of carbonates in the micropores and macropores of the cement, leading to a reduction of porosity in the carbonation front. Conversely, the dissolution front is a zone of high porosity. This effect leads to a weakening of Portland cement in terms of mechanical properties.